Climate and Forest Wildfire in the Western United States: recent trends and projections

September 15, 2006

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with contributions from

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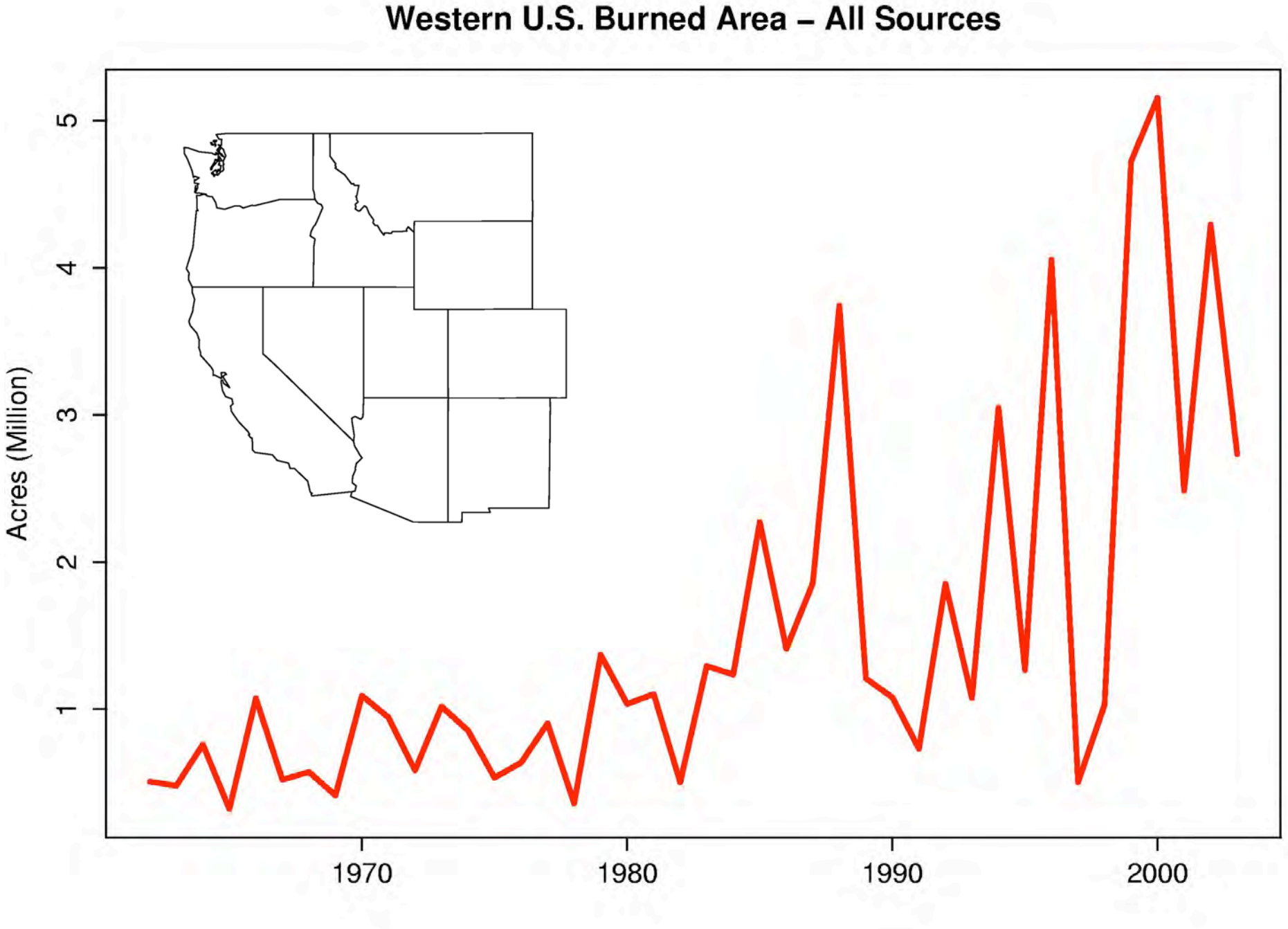
with support from

California Energy Commission - CCCC

NOAA OGP - CAP

USFS - RMRS, SRS


Western U.S. Burned Area – All Sources
Acres (Million)
1
2
3
4
5
1970
1980
1990
2000

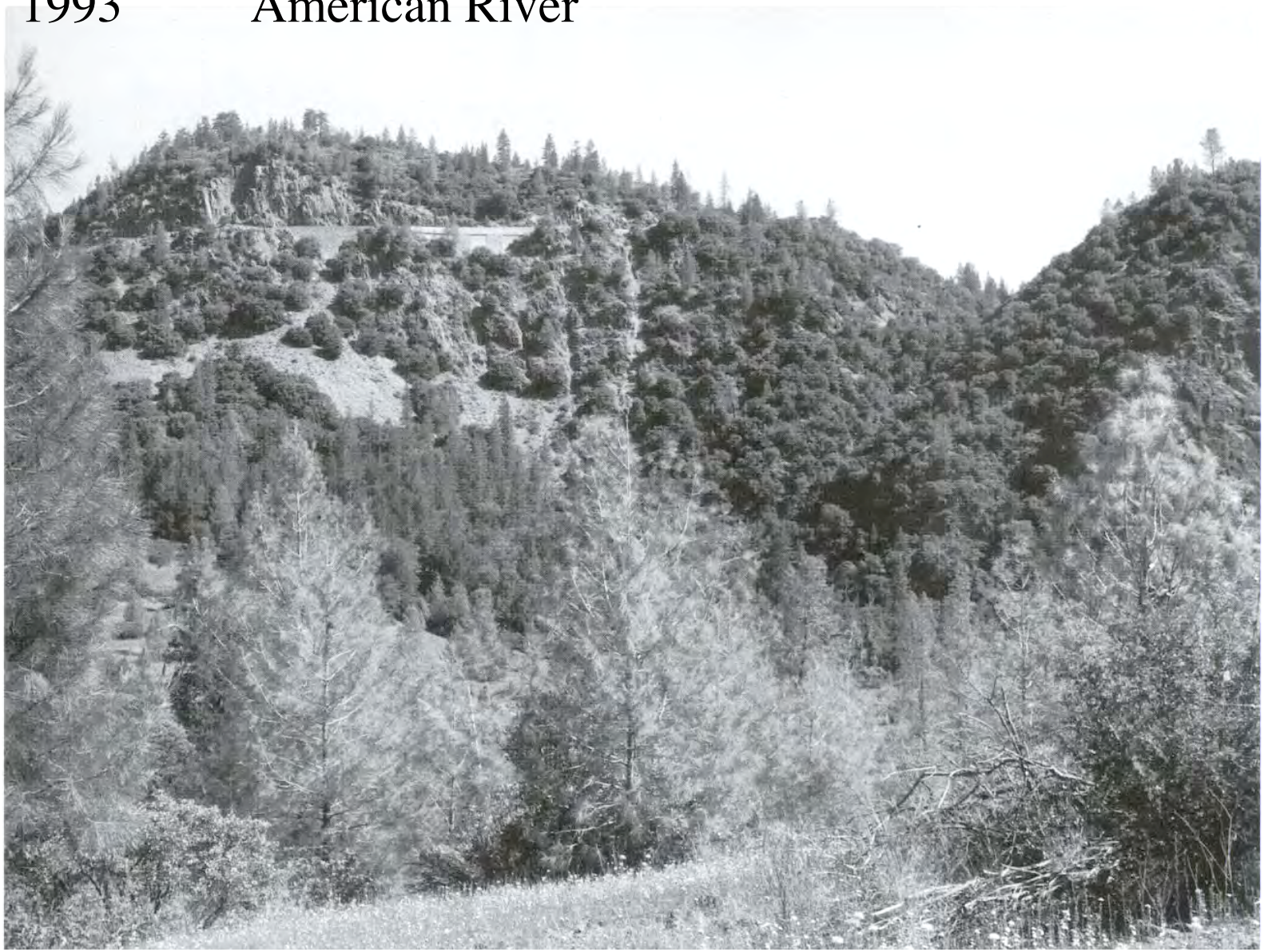
Why Has Forest Wildfire Increased?

- **Management**
  - Grazing and fire suppression reduced burned area
  - Reduced burned area led to biomass accumulation in some forests
  - Increased biomass reduced the effectiveness of suppression efforts
- **Climate**
  - Fire activity driven by antecedent moisture and concurrent drought
  - Climatologic extremes have been more frequent in recent decades

Consequences? Fuel accumulation reduces effectiveness of suppression

1867 American River

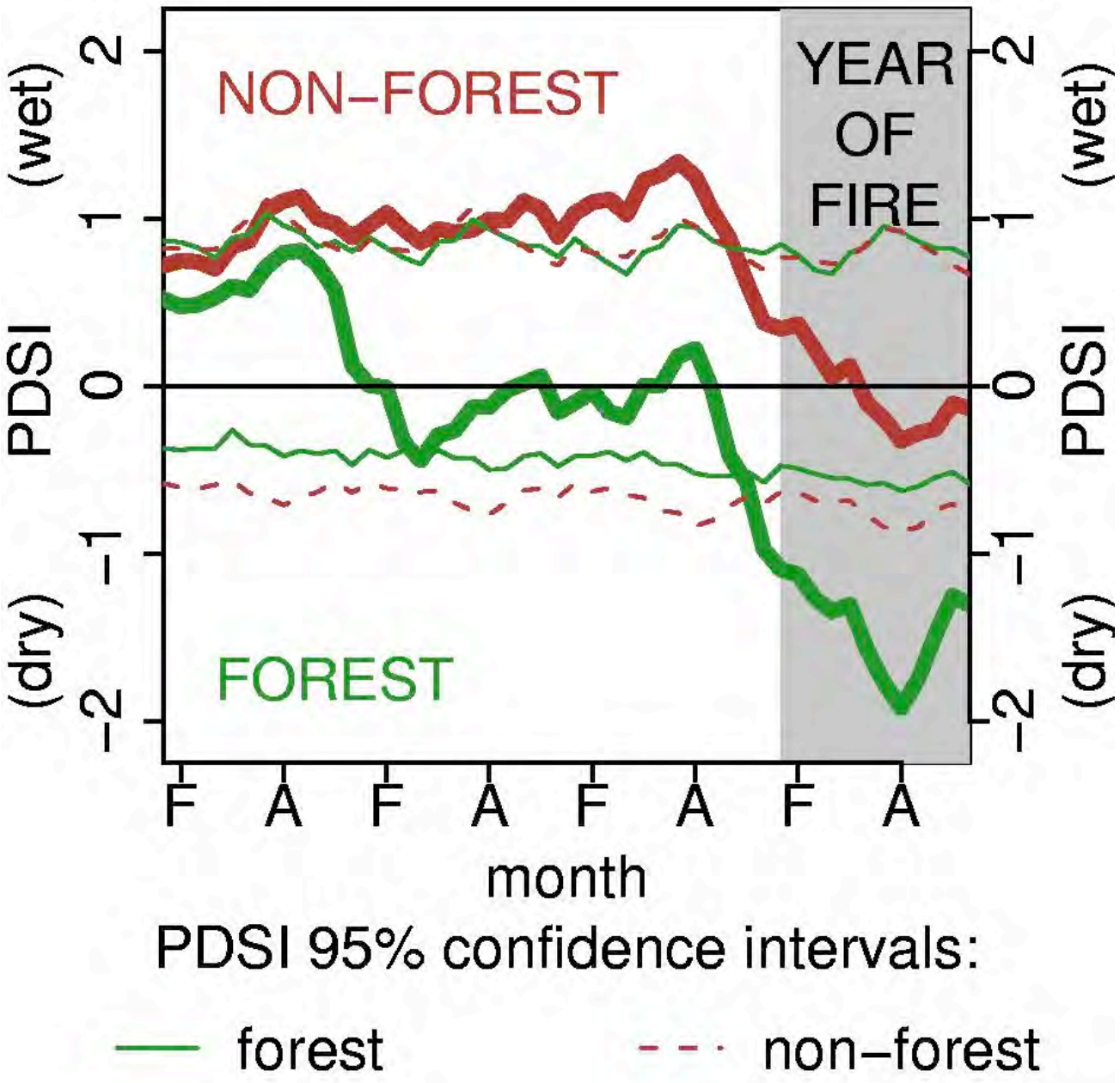
1993 American River



Why Has Wildfire Activity Increased?

- **Management**
  - fire suppression reduced burned area mid-20th century
  - Reduced burned area led to biomass accumulation in some forests
  - Increased biomass reduced the effectiveness of suppression efforts
- **Climate**
  - Fire activity driven by antecedent moisture and concurrent drought
  - Climatologic extremes have been more frequent in recent decades

Composite Drought Indices for Wildfire by Coarse Vegetation Class



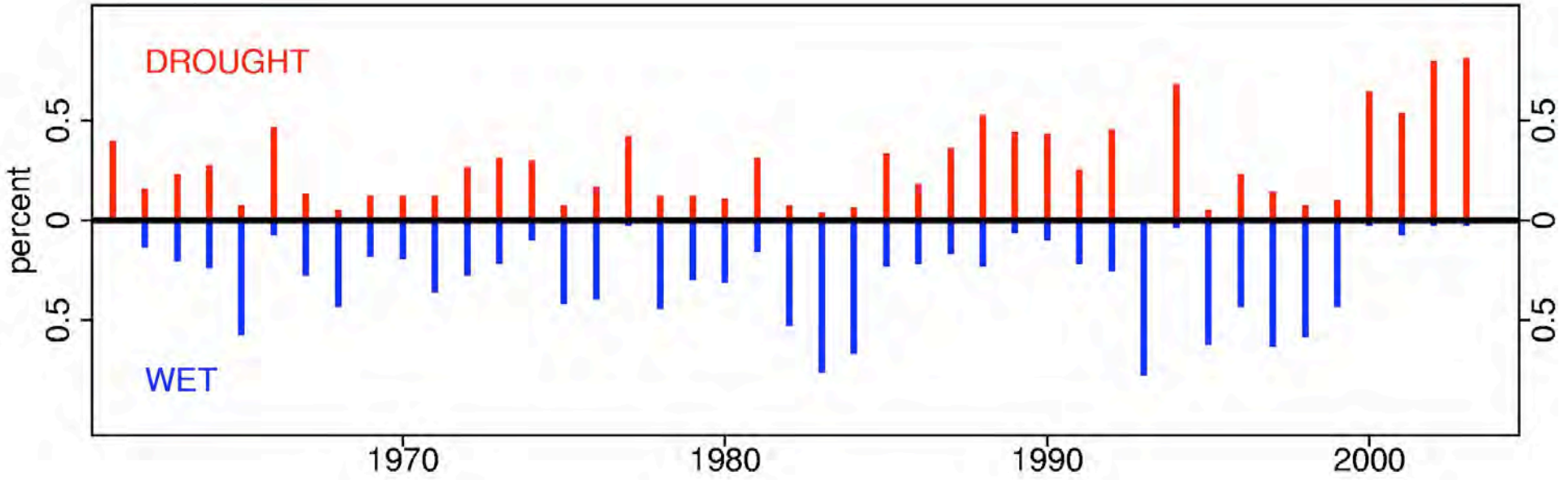
A Useful Over-Simplification:

Moisture-Limited Fire Regimes

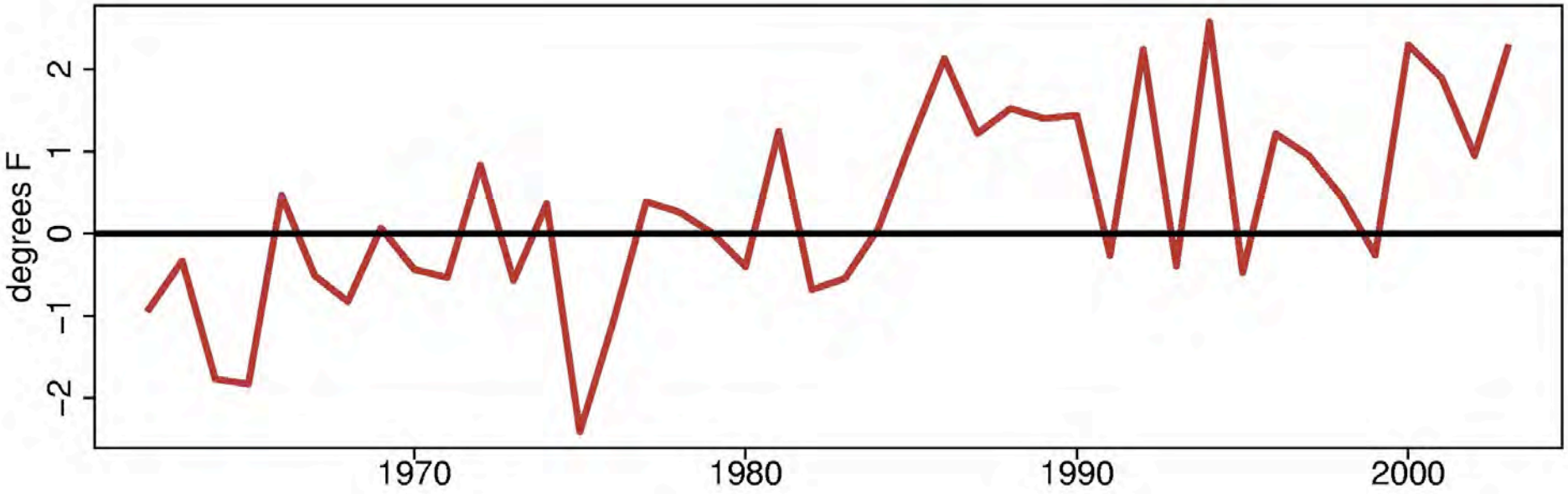
vs

Energy-Limited Fire Regimes

Percent of West in Drought or Wet Conditions



Mean Western MAMJJA Temperature

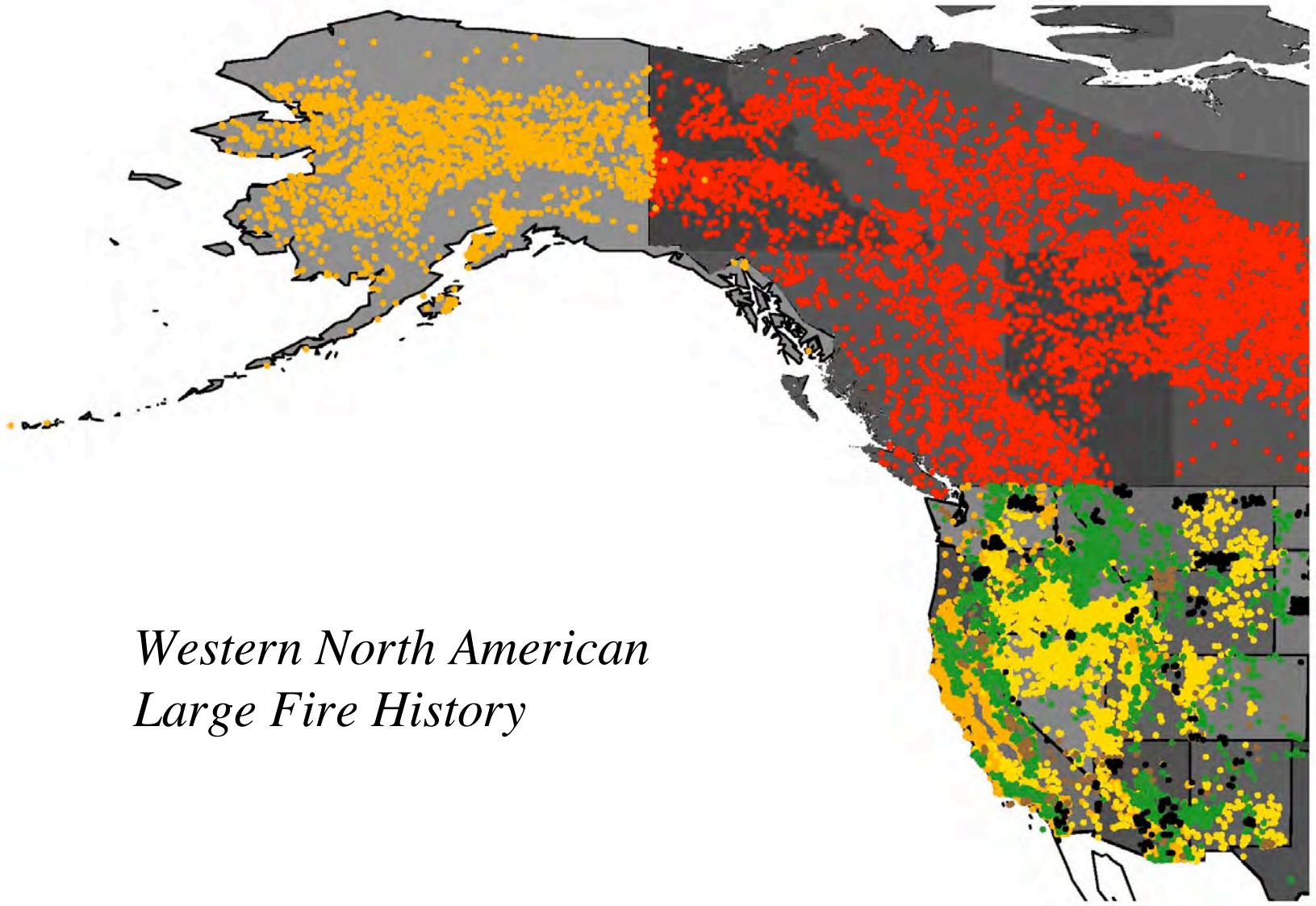


Research Questions

- What kinds of fire have increased?
  - ie, fuel limited and/or energy limited?
- Where has fire activity increased?
- Why has fire activity increased?
  - ie, why some places and not others?
  - How much can hydro-climate explain?
- What are the implications for climate change?

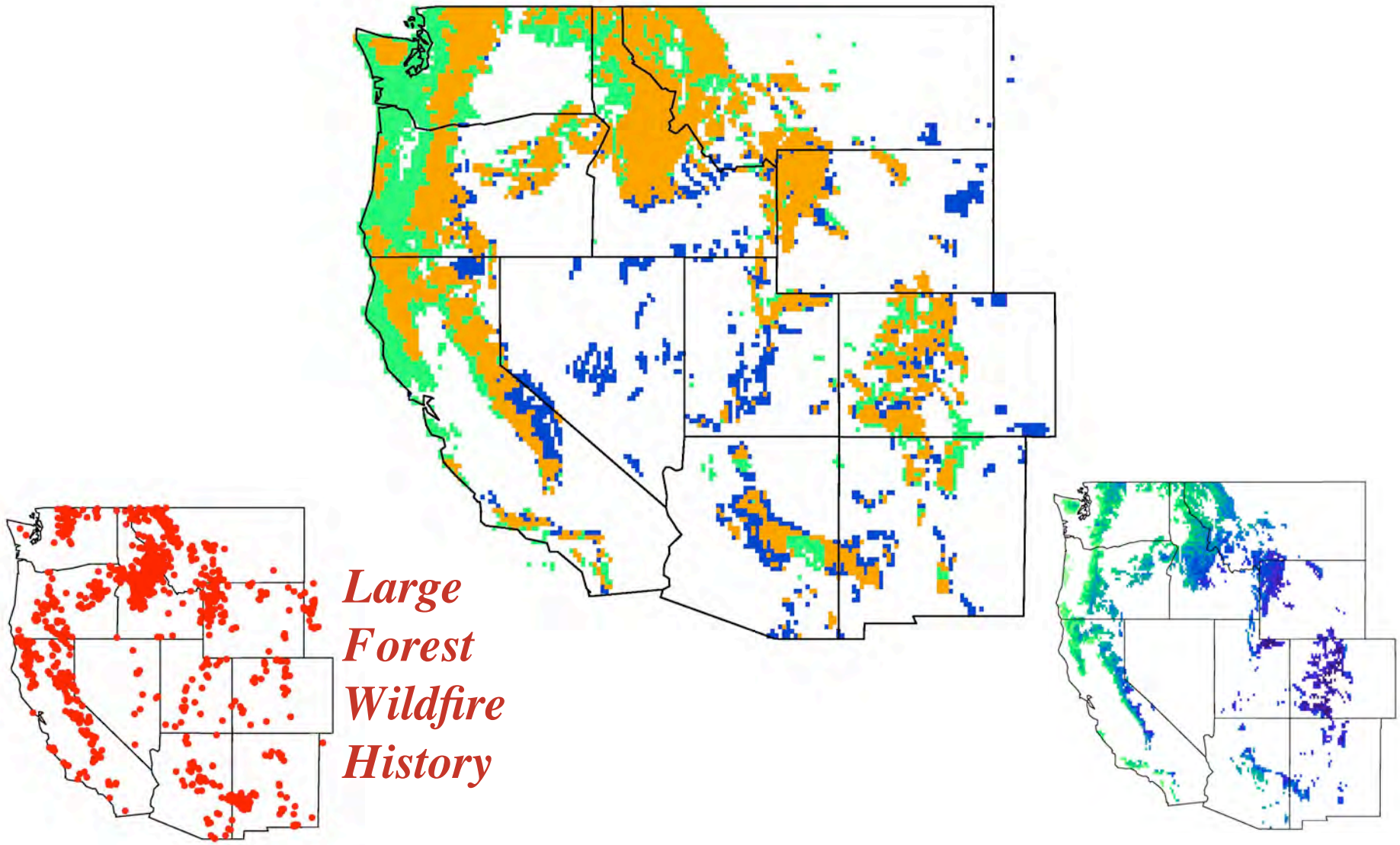
Fire History Data

- Federal Land Agencies' Fire Records
  - USFS & NPS units reporting 1970-2003
  - BIA units reporting 1972-2003
  - BLM units reporting 1980-2003
- Large Fires (> 400 ha (1000 acres))
- Size, Location, Elevation
- Dates: Discovery and Control
- Vegetation Type: Forest/Not Forest
- Missing values filled in from LDAS

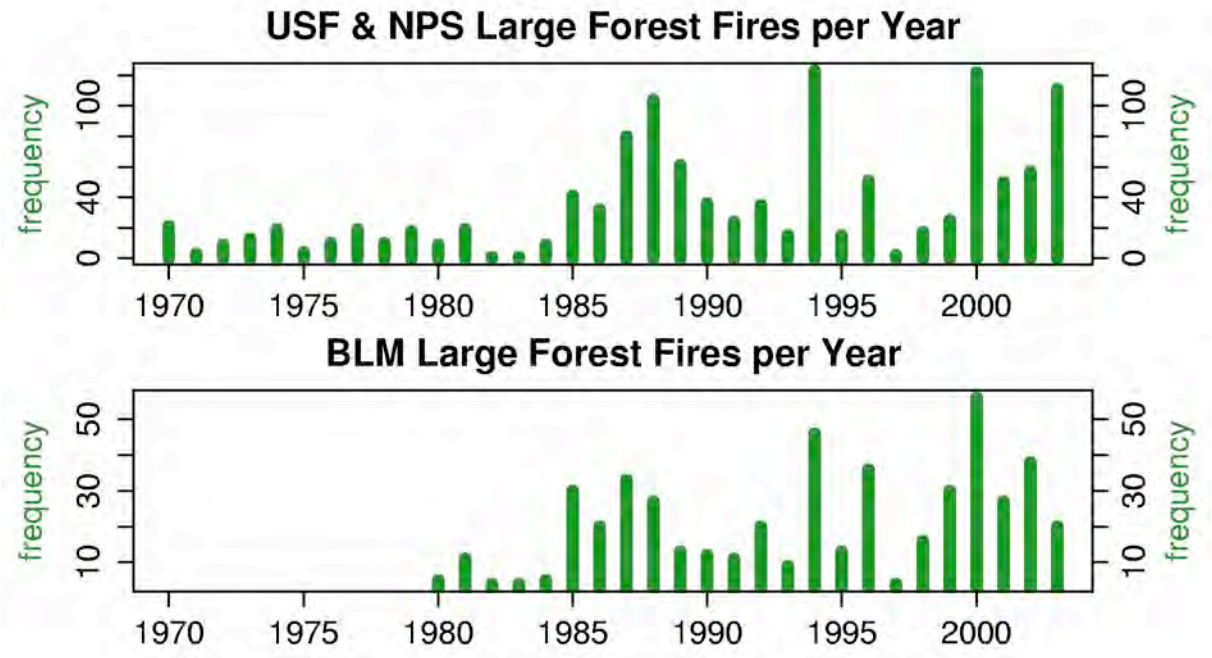


Western North American
Large Fire History

Region of Analysis:
Western US Forest Area Reporting Wildfires Since 1970

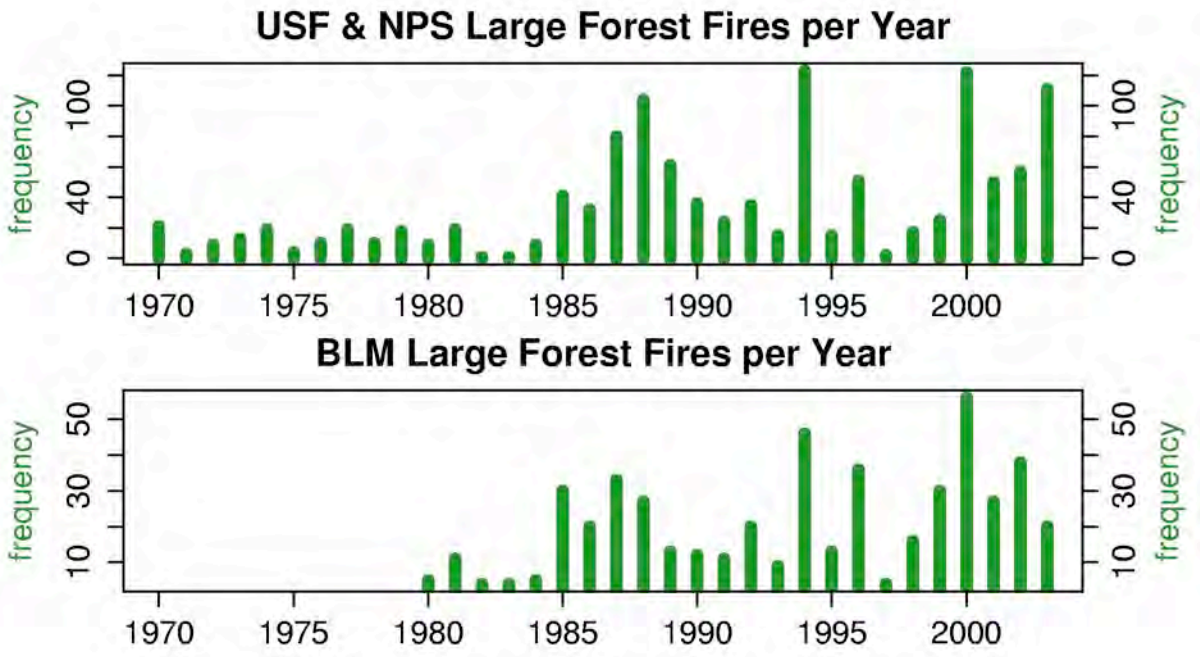


Large Forest Wildfire History



Since the mid-1980s

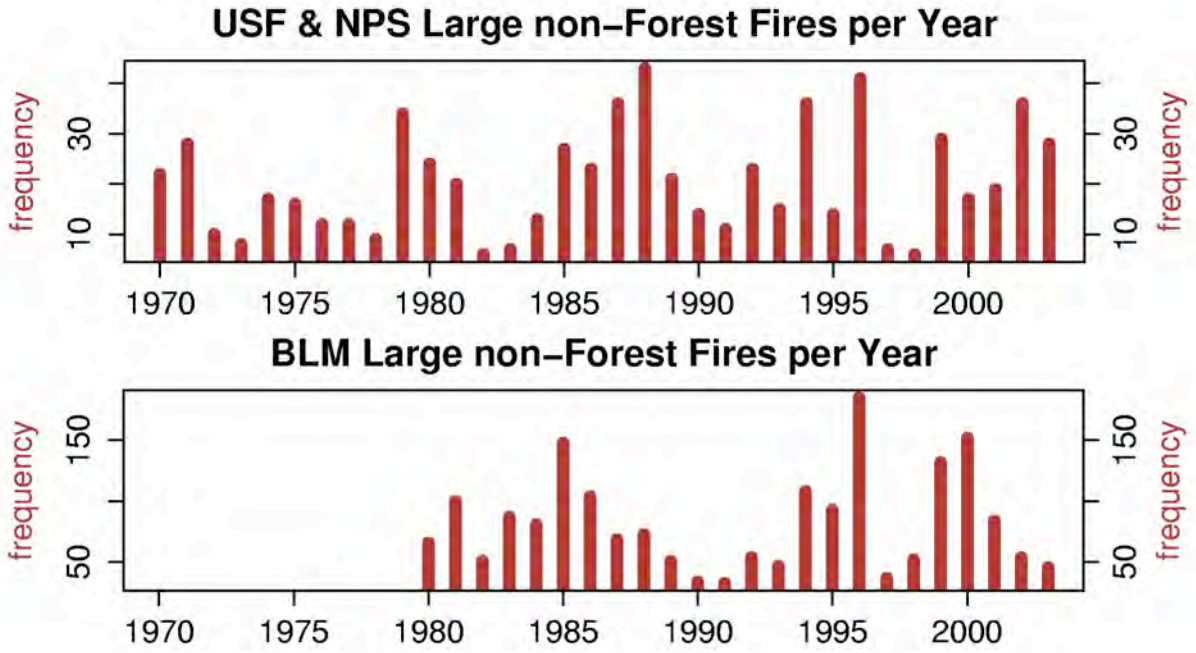
Large Forest Wildfires Have Increased 300%



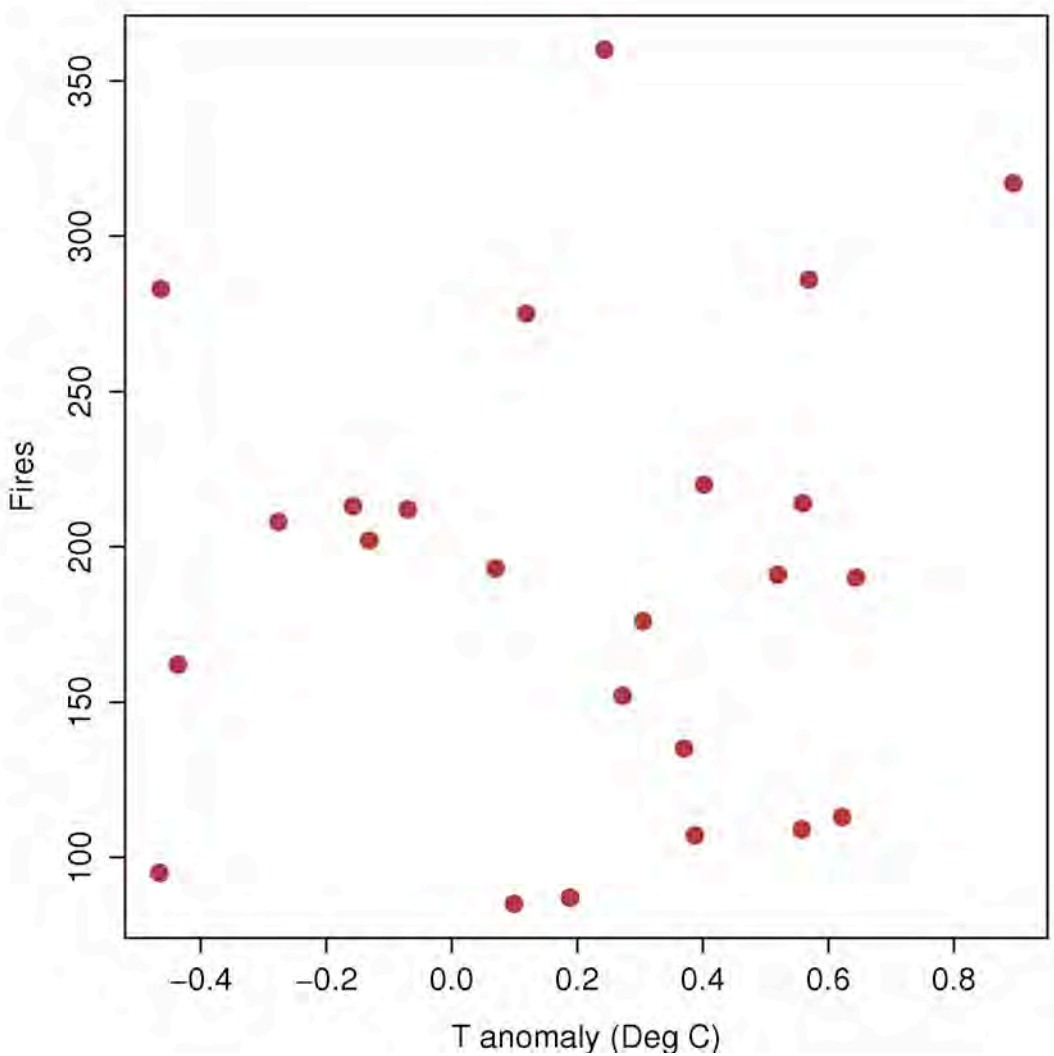
Since the mid-1980s

Large Forest Wildfires Have Increased 300%

Other Large Wildfires Have Not Changed Significantly

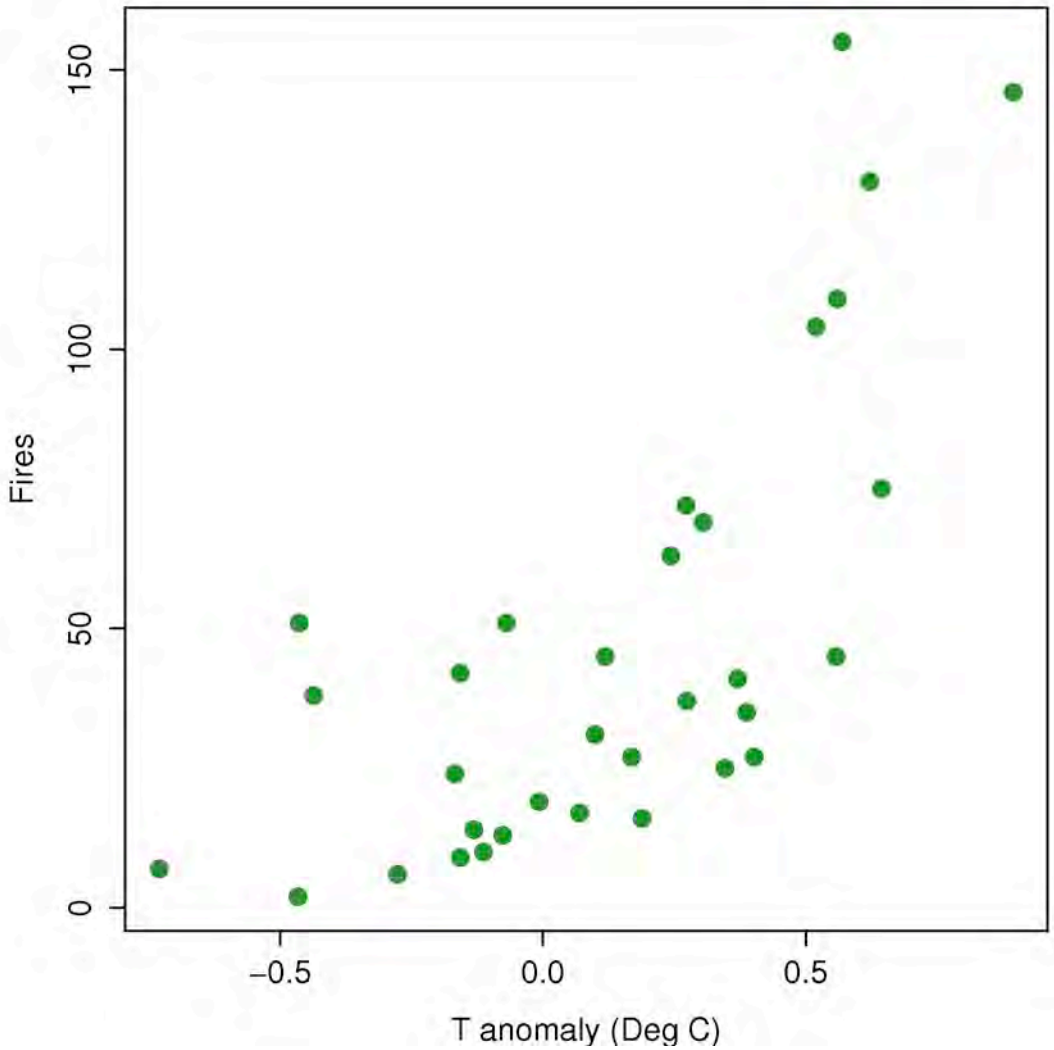


Grass/Shrub Fires and Temperature

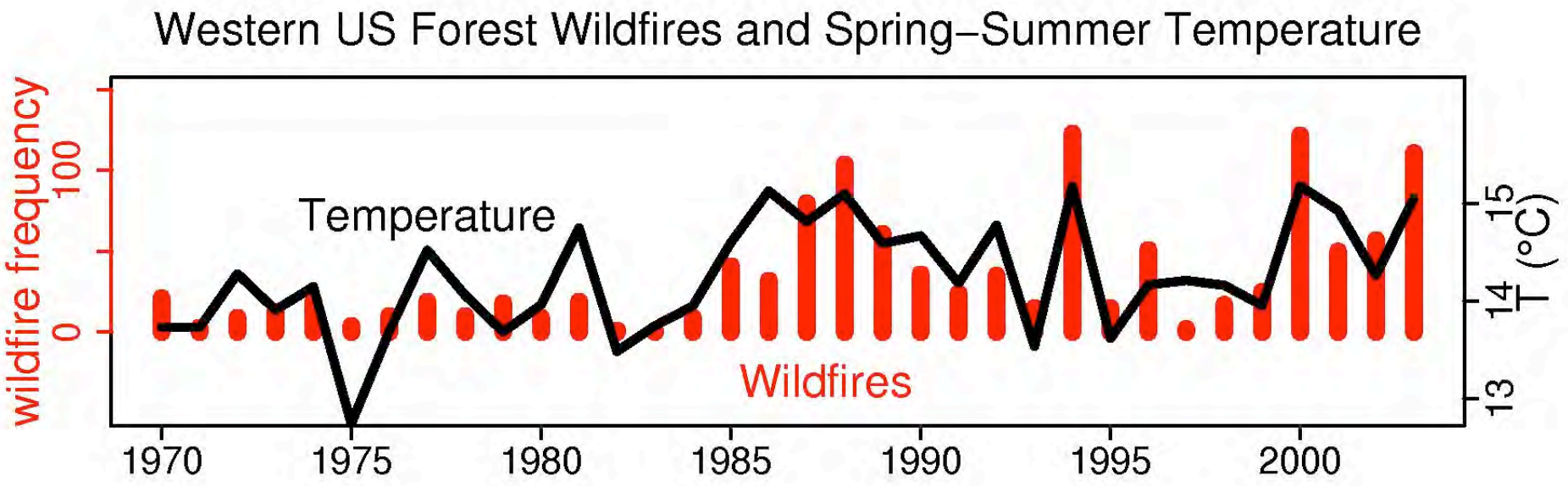


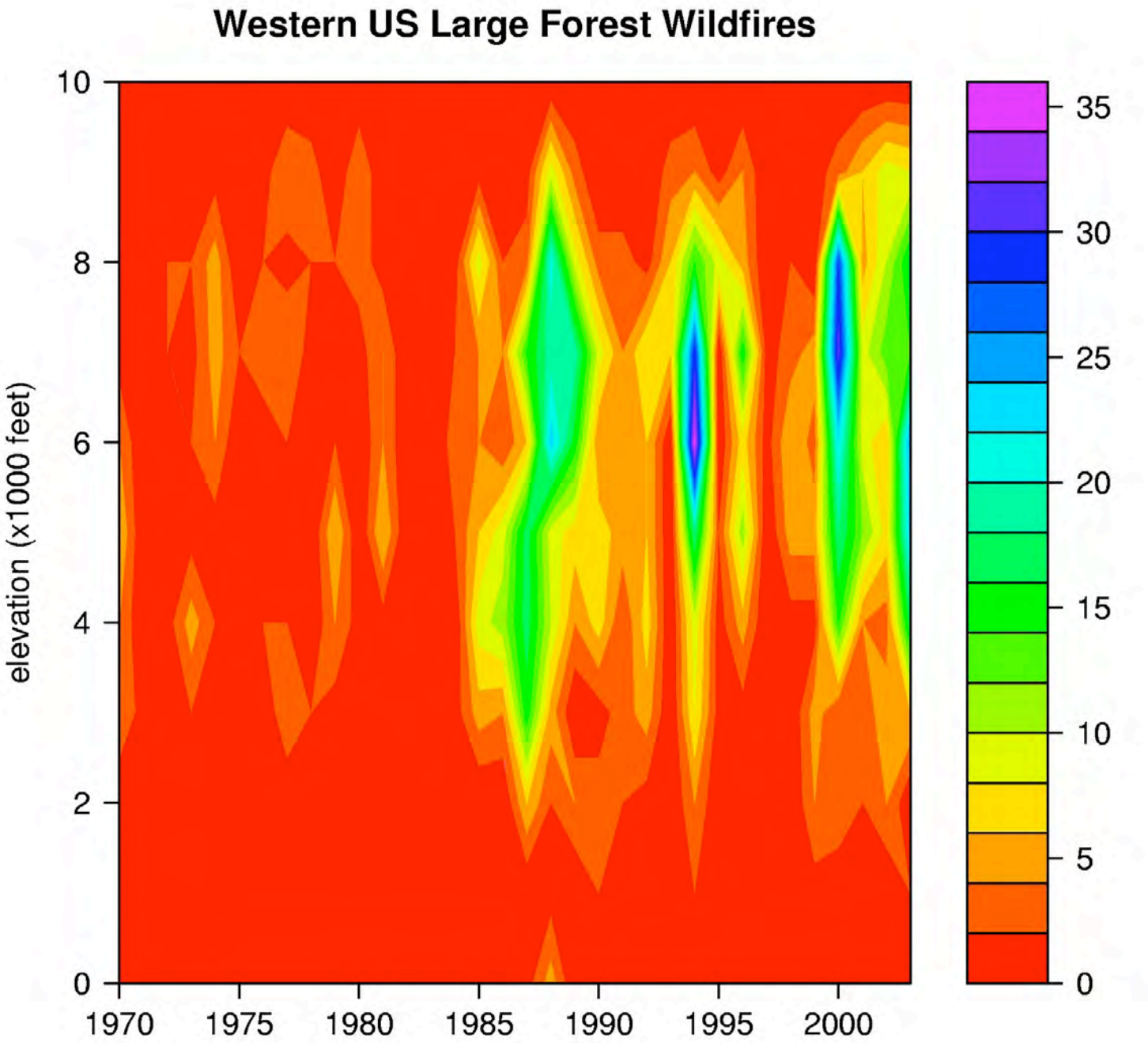
Correlation: 0.08

Forest Fires and Temperature

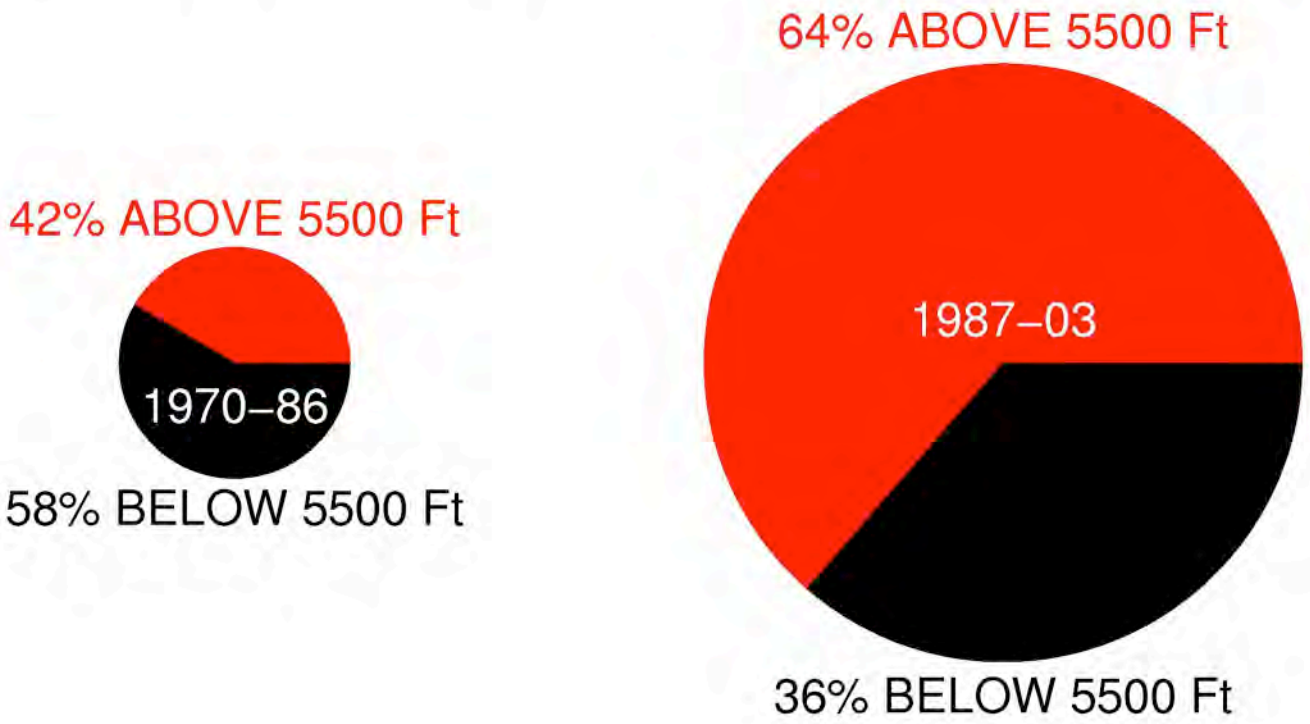


Correlation: 0.70

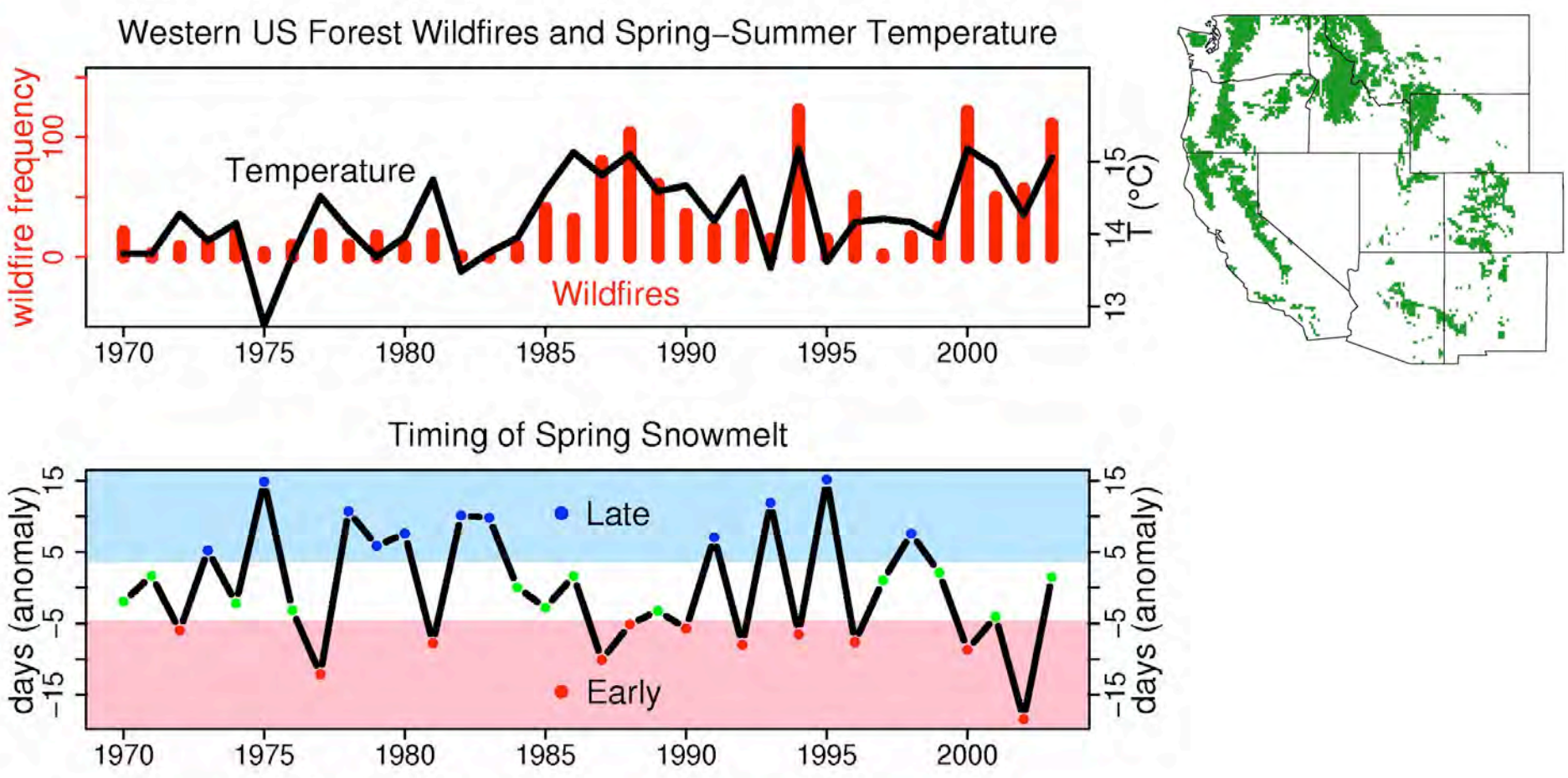

Western US Forest Wildfires and Spring–Summer Temperature
wildfire frequency
0
100
Temperature
Wildfires
1970
1975
1980
1985
1990
1995
2000
13
14
15
T (°C)

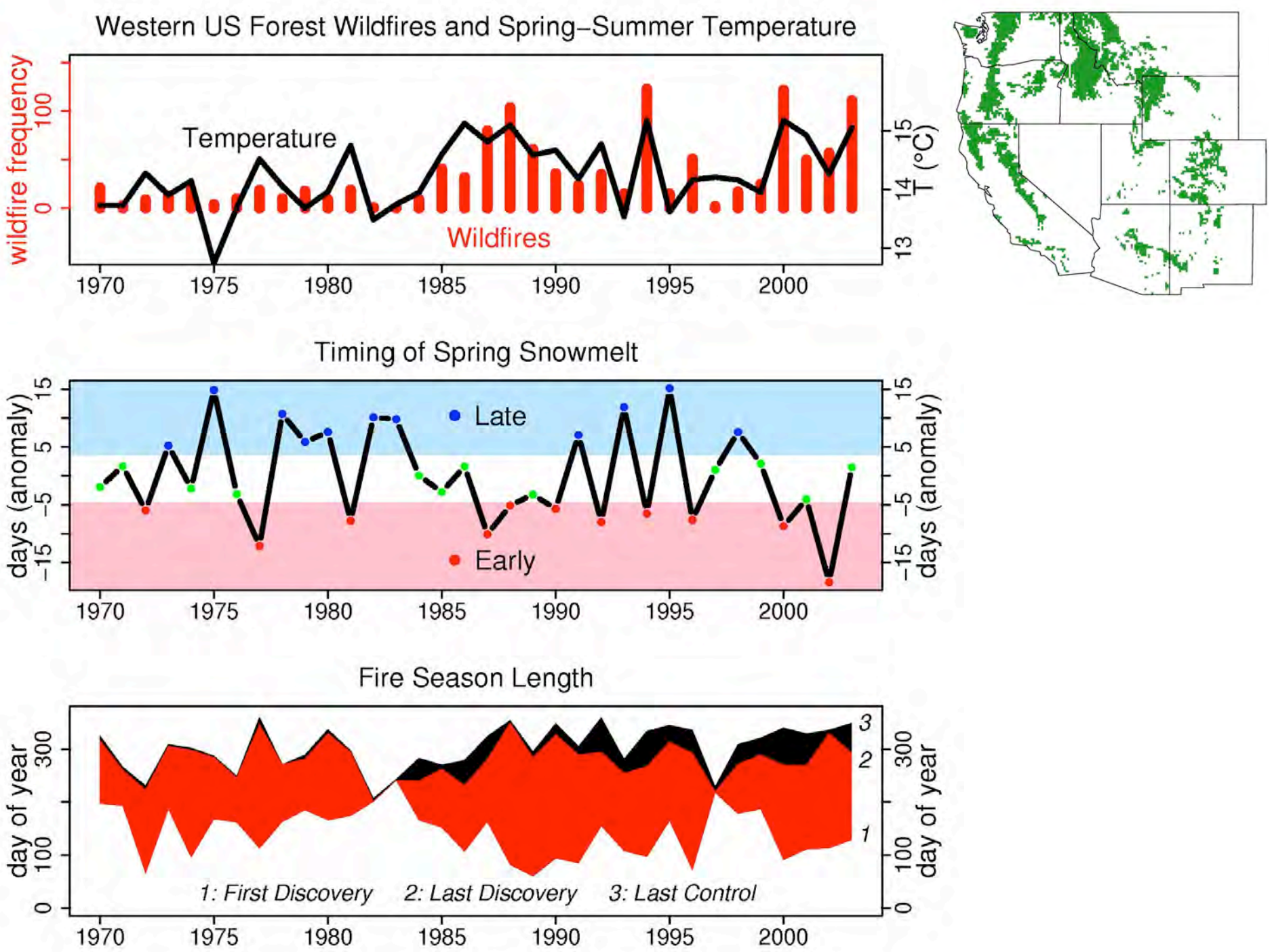

Western US Large Forest Wildfires
elevation (x1000 feet)
10
8
6
4
2
0
1970
1975
1980
1985
1990
1995
2000
35
30
25
20
15
10
5
0

1987–03 FOREST AREA BURNED IS 6.7 TIMES 1970–86 AREA

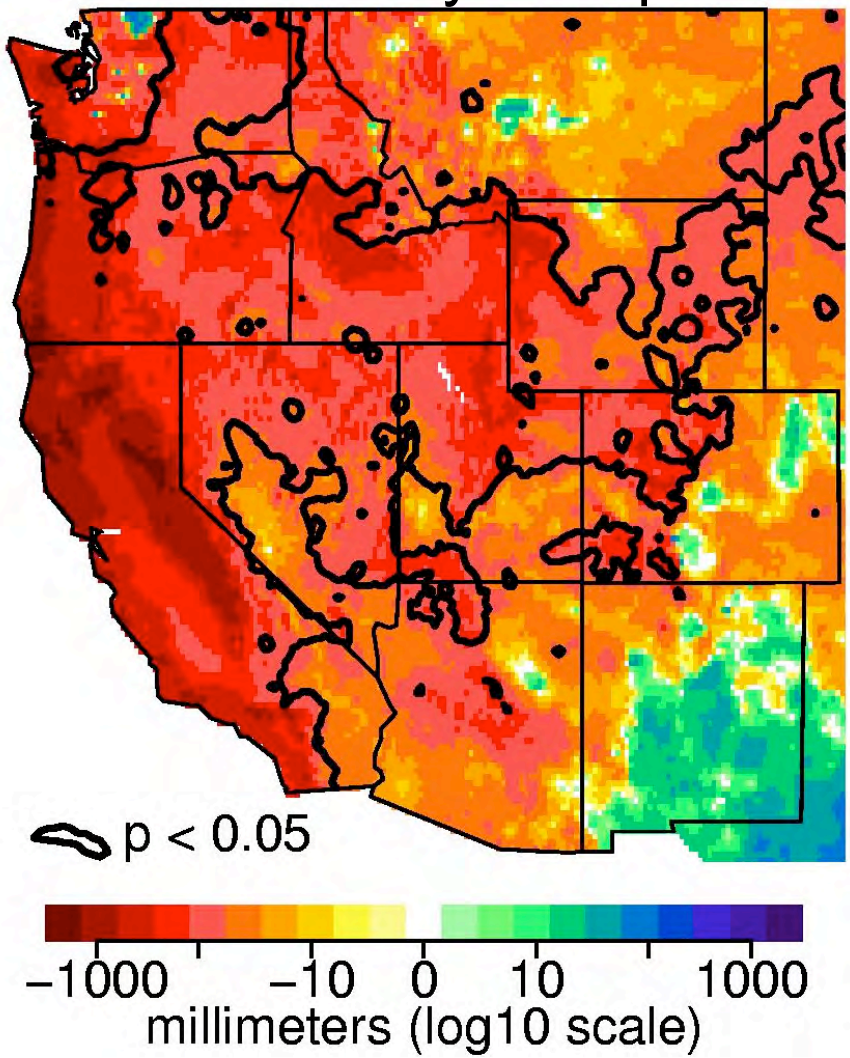


AREA BURNED IN FORESTS IN FIRES > 1000 ACRES, USF & NPS UNITS
REPORTING FROM 1970 ON

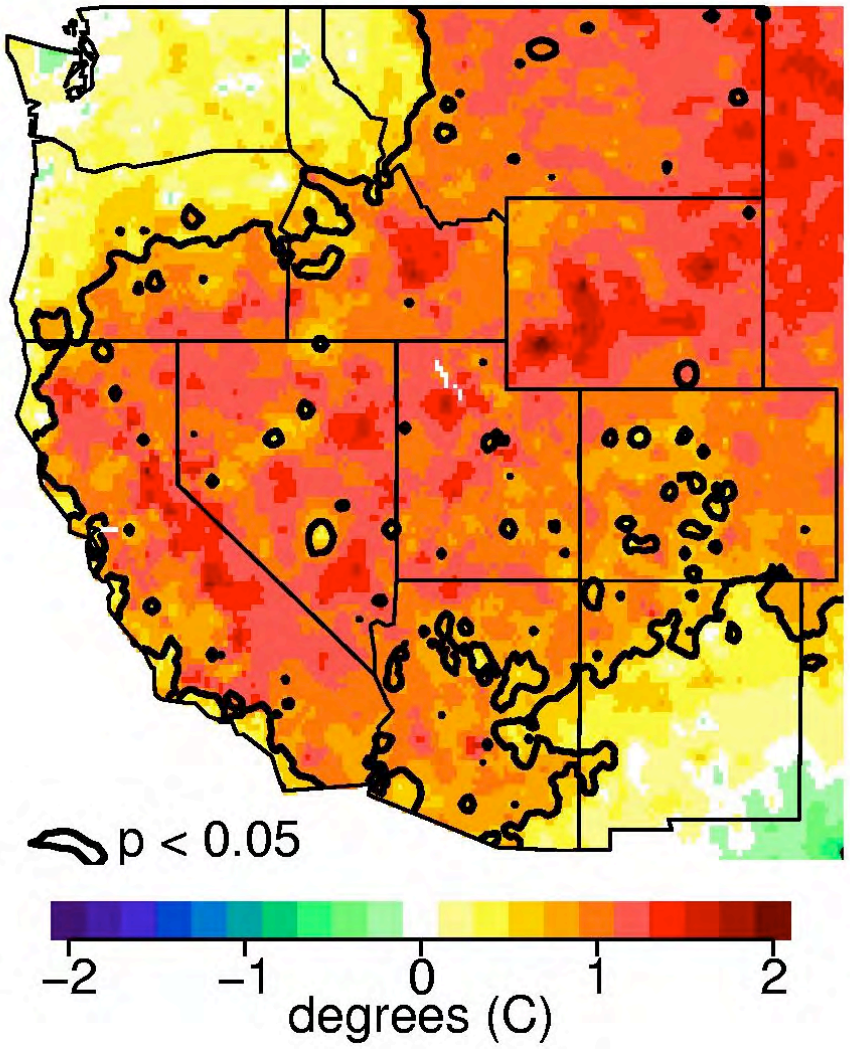

Western US Forest Wildfires and Spring–Summer Temperature
wildfire frequency
0
100
Temperature
Wildfires
13
14
15
T (°C)
1970
1975
1980
1985
1990
1995
2000
Timing of Spring Snowmelt
days (anomaly)
−15
−5
5
15
Late
Early
1970
1975
1980
1985
1990
1995
2000

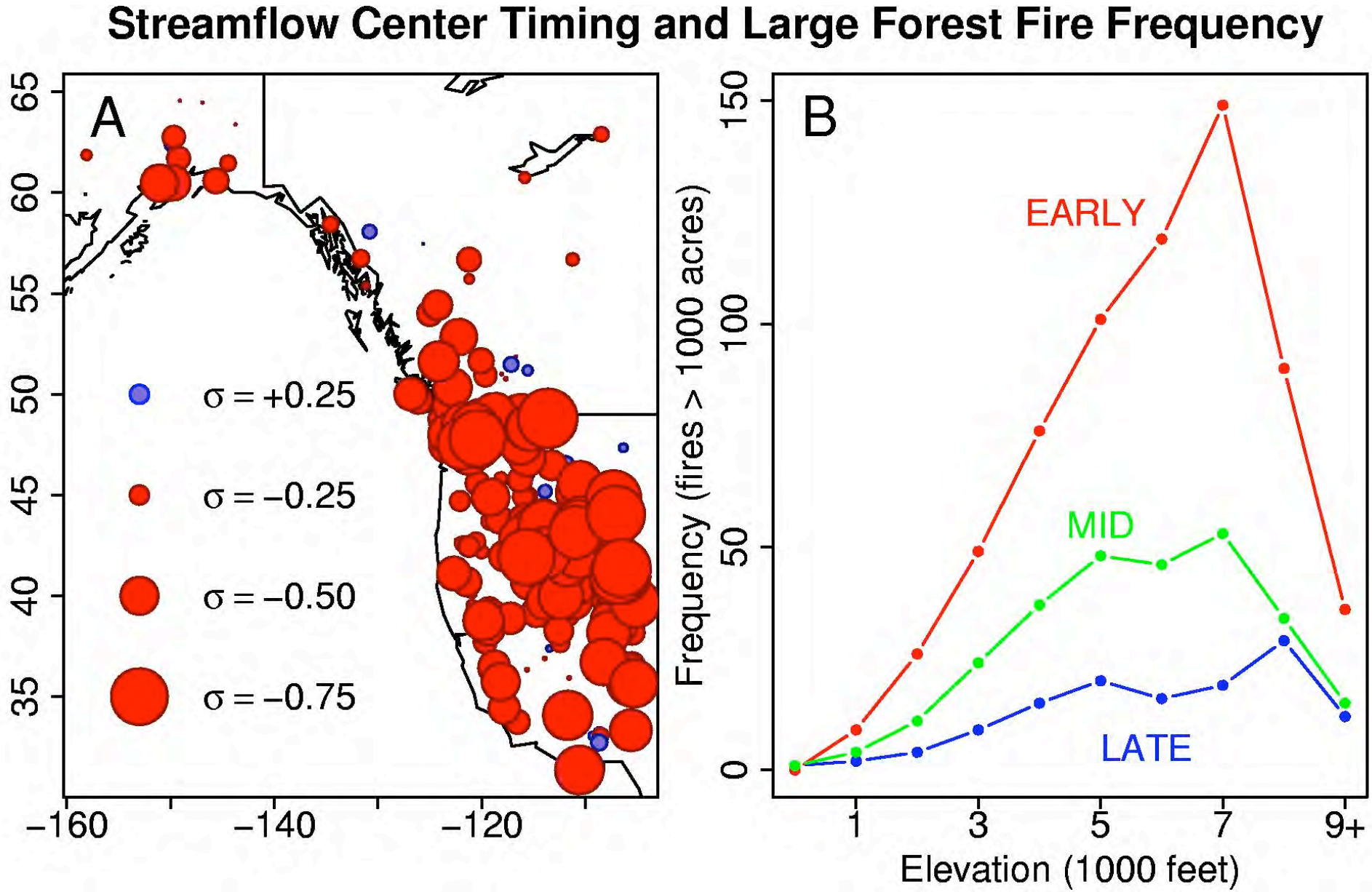

Western US Forest Wildfires and Spring–Summer Temperature
wildfire frequency
0
100
Temperature
Wildfires
13
14
15
T (°C)
1970
1975
1980
1985
1990
1995
2000
Timing of Spring Snowmelt
days (anomaly)
−15
−5
5
15
Late
Early
Fire Season Length
day of year
0
100
300
1
2
3
1: First Discovery
2: Last Discovery
3: Last Control

Early - Late
Oct to May Precip

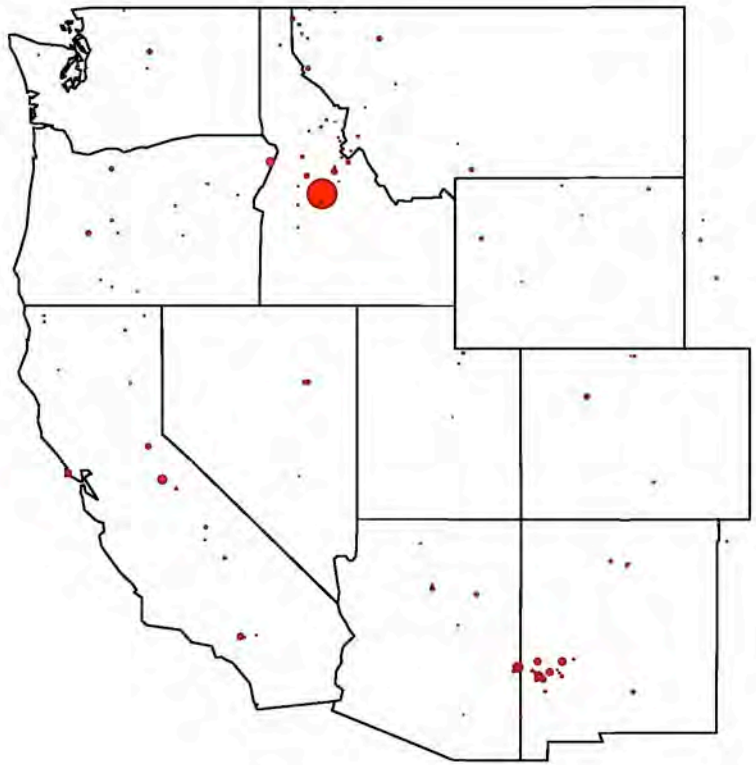


Early - Late
Mar to Aug Temp

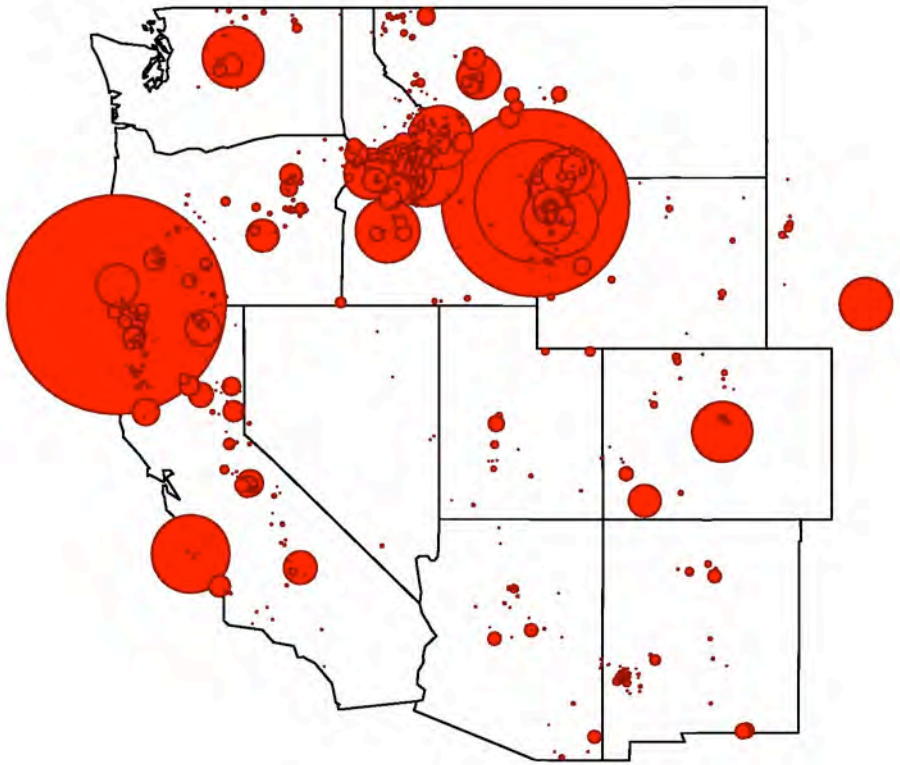



Streamflow Center Timing and Large Forest Fire Frequency
A
σ = +0.25
σ = −0.25
σ = −0.50
σ = −0.75
65
60
55
50
45
40
35
−160
−140
−120
B
EARLY
MID
LATE
Frequency (fires > 1000 acres)
150
100
50
0
1
3
5
7
9+
Elevation (1000 feet)

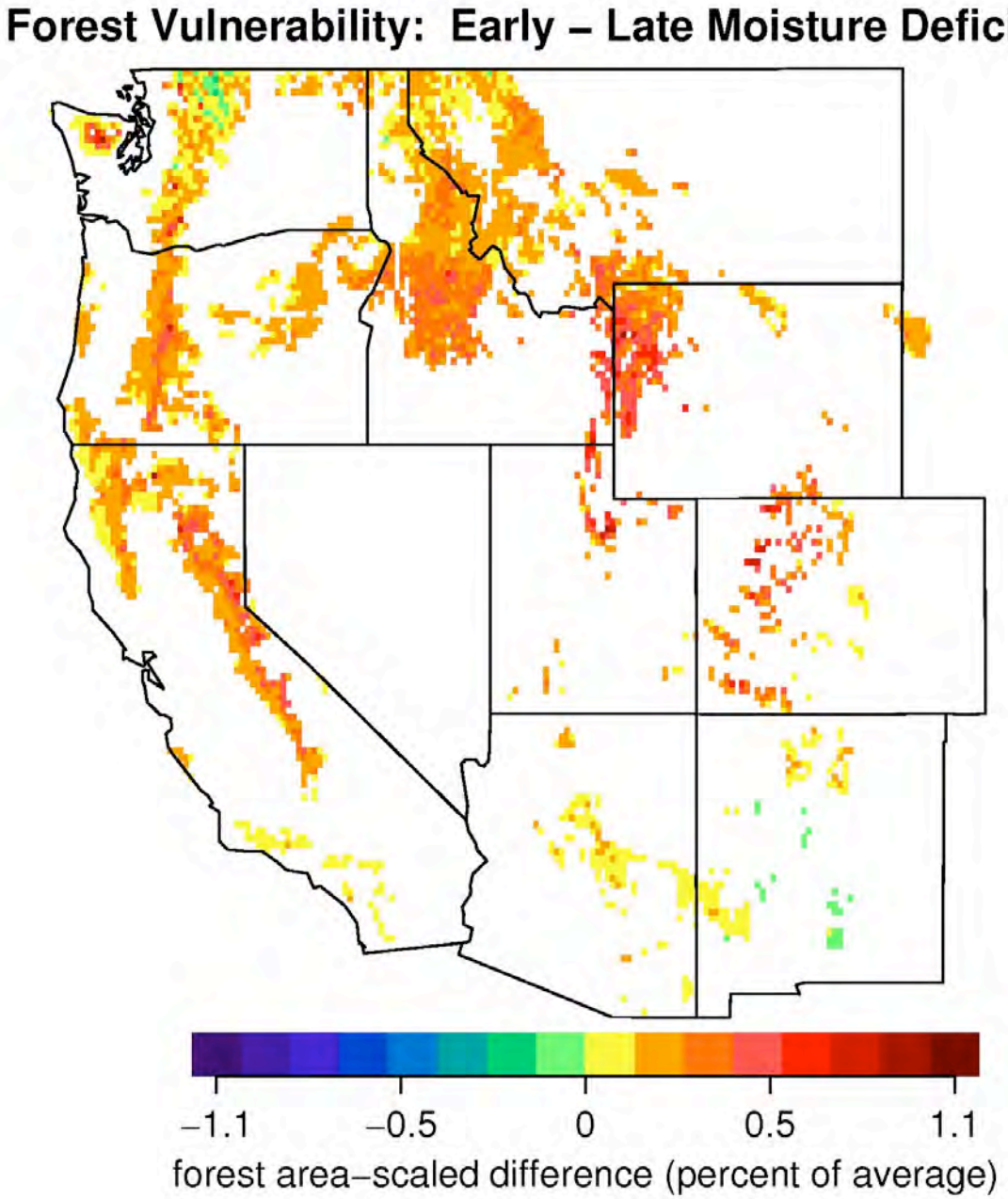
Late Snowmelt Years

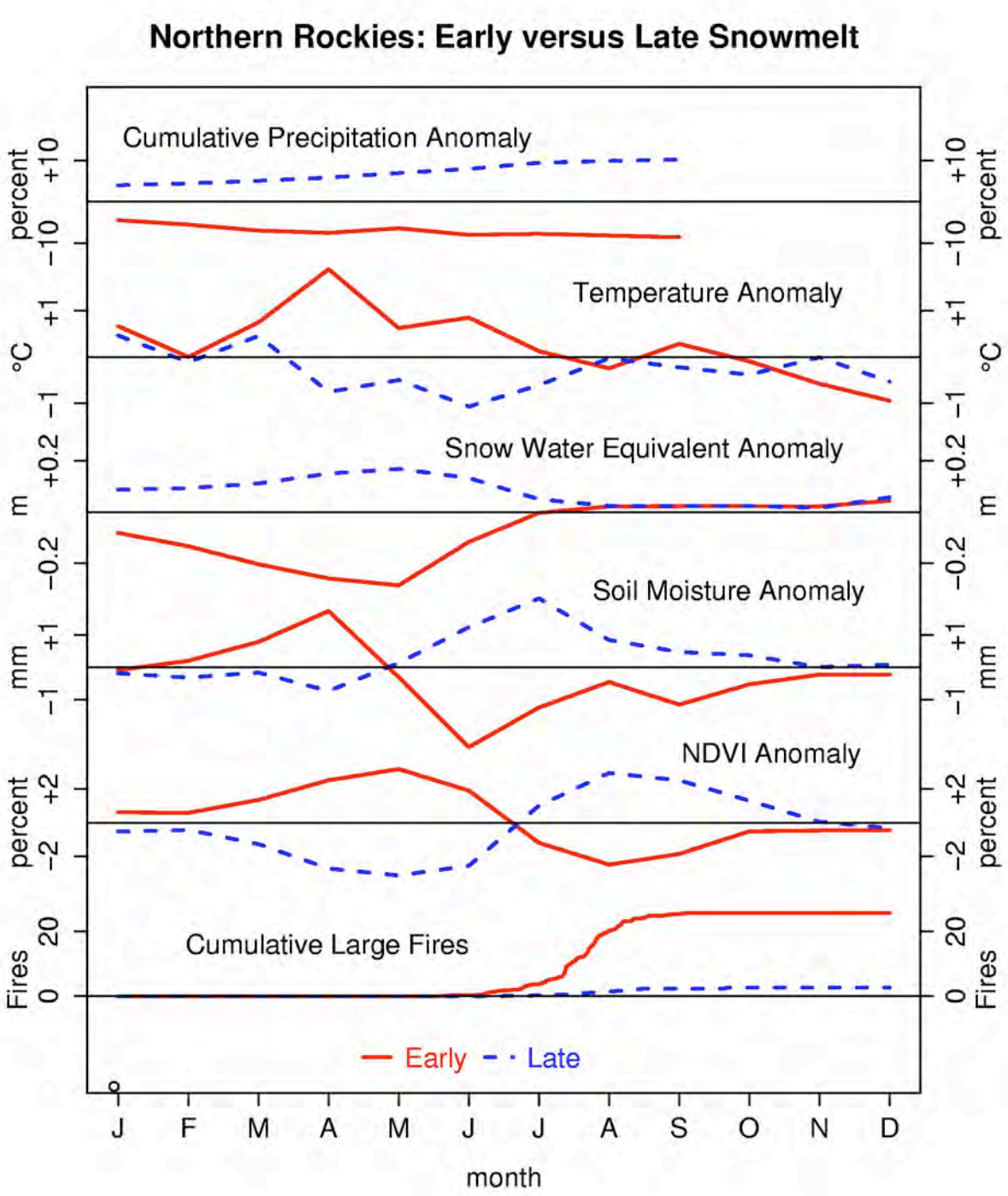


Early Snowmelt Years



1970 - 2003, Park and Forest Service Fires over 1000 acres


Forest Vulnerability: Early – Late Moisture Deficit
−1.1
−0.5
0
0.5
1.1
forest area−scaled difference (percent of average)


Northern Rockies: Early versus Late Snowmelt
Cumulative Precipitation Anomaly
Temperature Anomaly
Snow Water Equivalent Anomaly
Soil Moisture Anomaly
NDVI Anomaly
Cumulative Large Fires
percent
°C
m
mm
percent
Fires
+10
−10
+1
−1
+0.2
−0.2
+1
−1
+2
−2
20
0
Early
Late
J
F
M
A
M
J
J
A
S
O
N
D
month

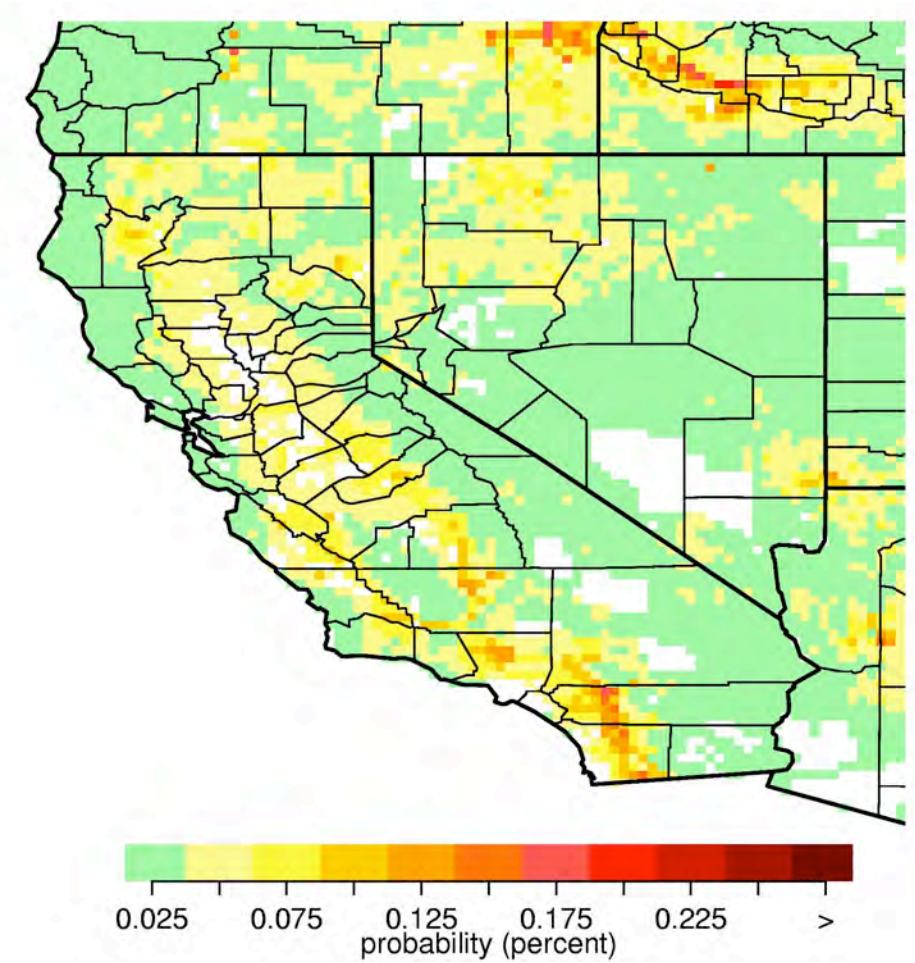
Climate Change Assessment for CA Wildfire

- Logistic Regression
- 1/8 degree gridded wildfire, downscaled climatic, and simulated hydrologic variables
- Proxy vegetation categories in statistical fire model vary over time
- VIC vegetation layer fixed
- Risk assessment based on fixed development: 2000 census
- Crude empirical estimates of damage ratio and improved ratio

Wildfire in California

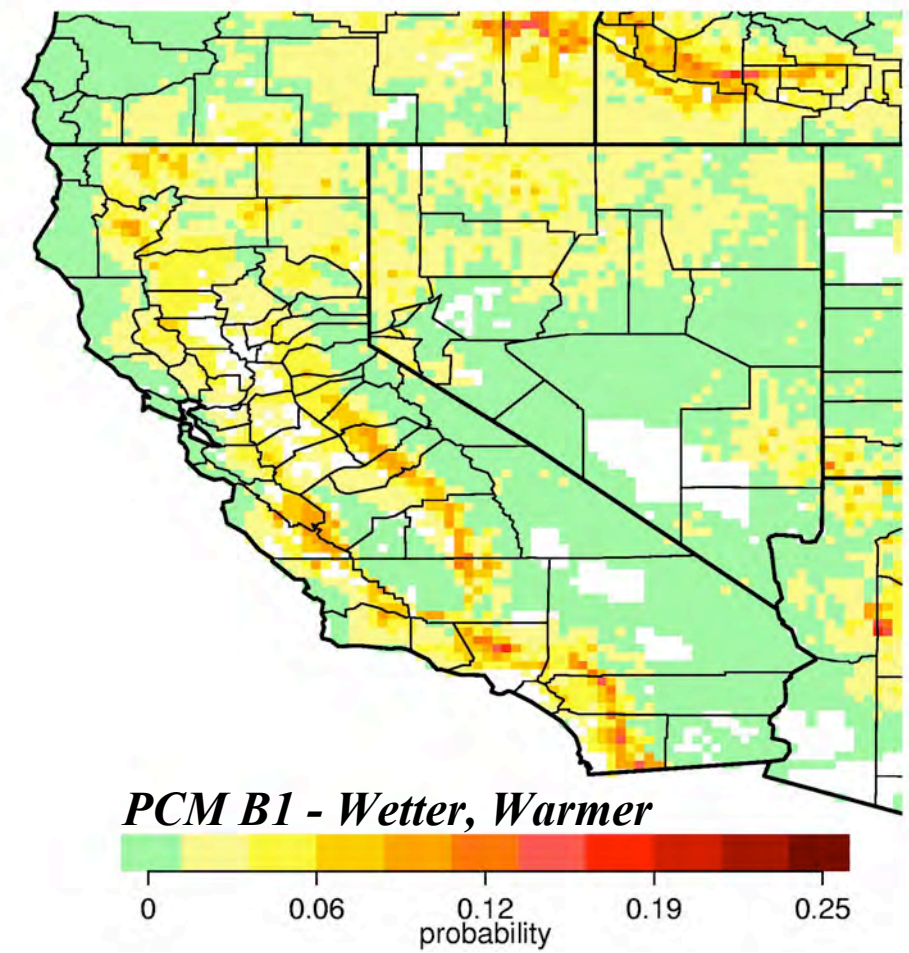
Currently, Highest California Wildfire Risks Are Mostly Concentrated in:

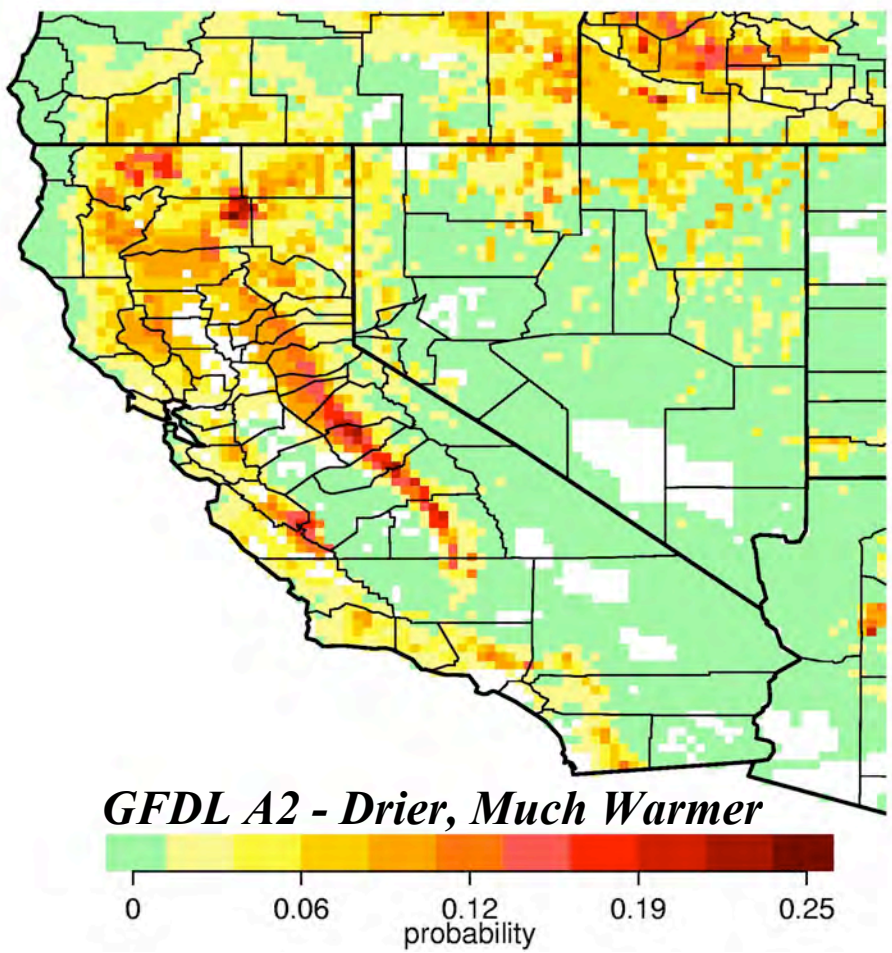
- **Coastal Southern California**
- **Sierra Nevada Foothills & Mountains** (< 7000 Ft Elevation)



Wildfire Scenarios

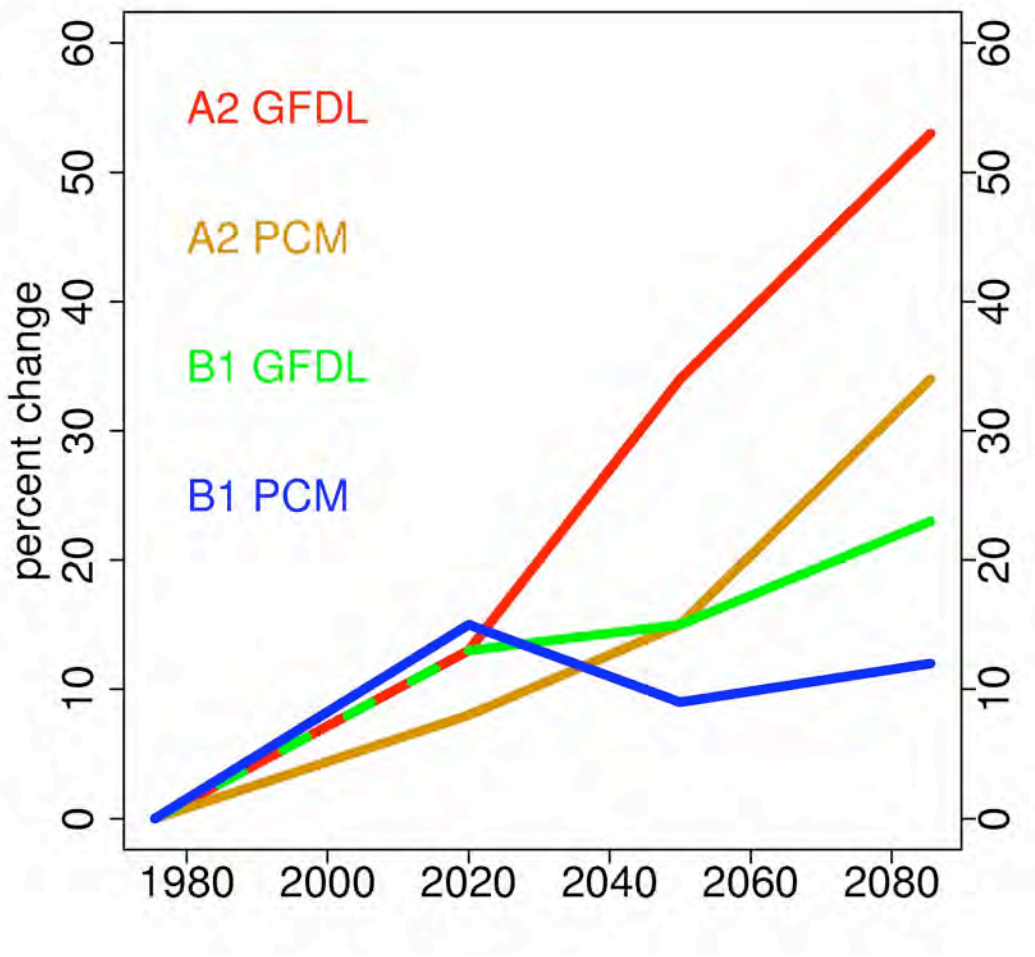
Our Scenarios Envision a Wide Range of Possible Futures…





Increased Wildfire Risks

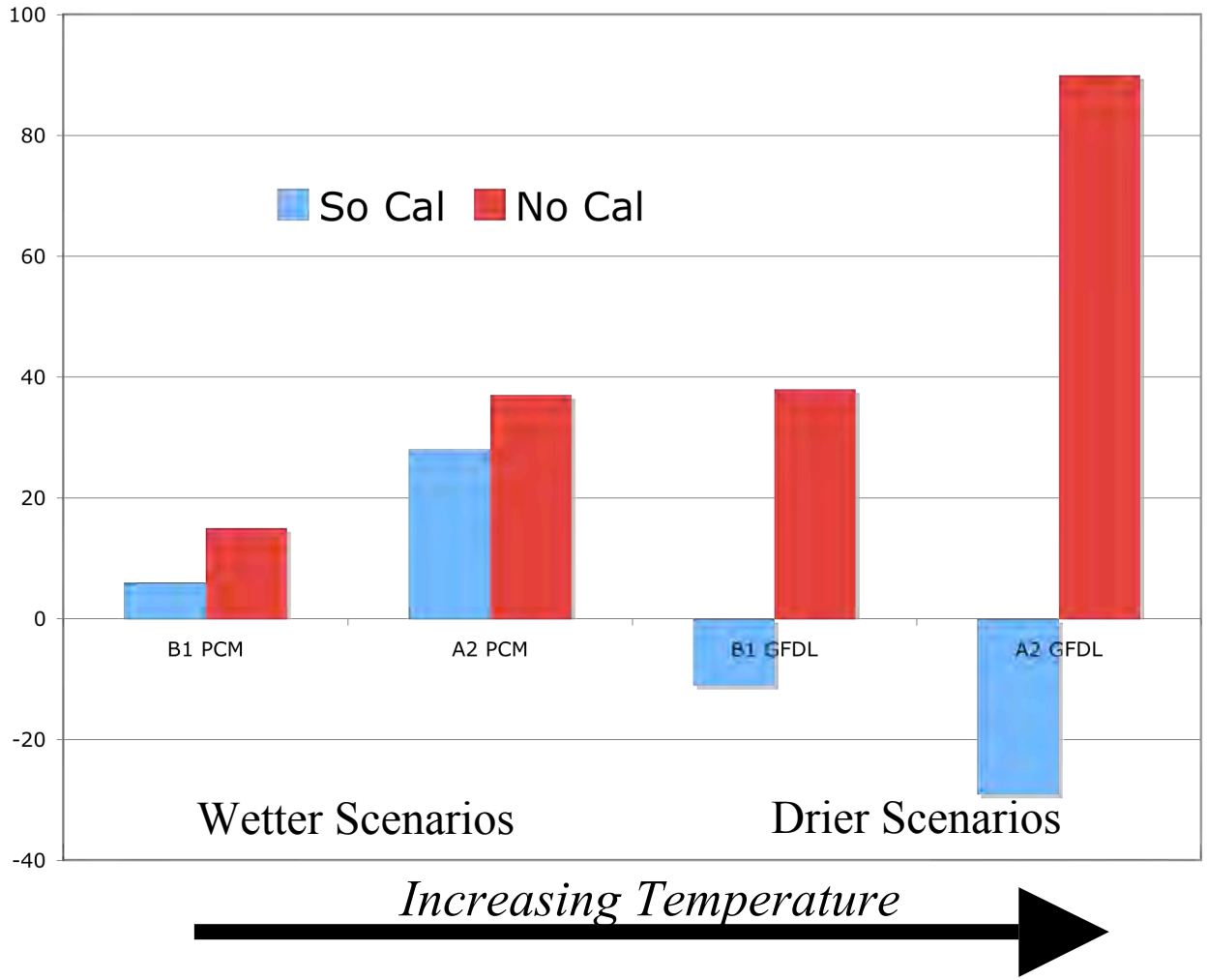
… But all of our Scenarios Result in Increased Fire Risks For California.



Different Impacts Within CA

The Greatest **Increased** CA Wildfire **Risks** are Concentrated **in** **North**ern California

Greater Uncertainty for Wildfire Risks **in** **South**ern California



Property Losses:Warning Signs

For the GFDL A2 Scenario (Warm & Dry), **Increased Property Losses in Northern** California.

Losses **Increase Northeast of Sacramento** into the Sierra Foothills.

Structures & Property Values Based on 2000 Census.

Full extent of **future risks depends On Development & Population Growth** in the Foothills and Mnts. Of the Sierra Nevada